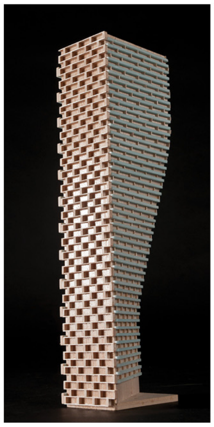
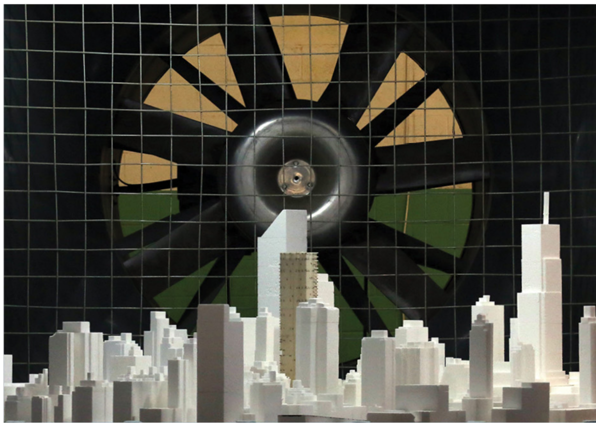
GRADIENTWIND
ENGINEERS & SCIENTISTS

DETAILED ENVIRONMENTAL NOISE STUDY

25 Pickering Place
Ottawa, Ontario

REPORT: GW24-031-Detailed Environmental Noise Study





May 3, 2024

PREPARED FOR
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PREPARED BY
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EXECUTIVE SUMMARY

This report describes a detailed environmental noise study performed for the proposed development comprising of two mixed-use buildings. Building A, rising 28 storeys and located on the west, while building B is a proposed to be 14 storeys and is on the east. The major contributors of roadway traffic noise are Tremblay Road, Belfast Road, and Highway 417. Additionally, rail traffic noise is present and due to proximity of the VIA Rail lines to the south, and O-train line to the north.

The assessment is based on theoretical noise calculation methods conforming to the City of Ottawa[1] and Ministry of the Environment, Conservation and Parks (MECP) NPC-300[2] guidelines, concept masterplan provided by Hobin Architecture in February 2024, with future roadway traffic volumes corresponding with the City of Ottawa's Official Plan (OP) roadway classifications and the Ministry of Transportation Ontario (MTO).

The results of the current analysis indicate that noise levels at the plane of window receptors due to roadway sources will range between 47 and 68 dBA during the daytime period (07:00-23:00) and between 40 and 63 dBA during the nighttime period (23:00-07:00). For railway sources, noise levels range between 51 and 57 dBA for the daytime period and 62 to 67 dBA during the nighttime period. The highest total noise level (i.e., 68 dBA) occurs at the north side of buildings A and B, which are most exposed to Tremblay Road, Highway 417, and the O-Train. Building components with a higher Sound Transmission Class (STC) rating will be required where exterior noise levels exceed 65 dBA, as indicated in Table 8.

Results of the calculations also indicate that the building will require central air conditioning, or similar mechanical system, which will allow occupants to keep windows closed and maintain a comfortable living/working environment. The following Type D Warning Clause[3] will be required on all Lease, Purchase and Sale Agreements, as summarized in Section 6.

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[1] City of Ottawa Environmental Noise Control Guidelines, January 2016

[2] Ministry of the Environment, Conservation and Parks (MECP), Environmental Noise Guideline – Publication NPC-300, August 2013

[3] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 8

Results indicate that stationary noise levels due to idle trains at the nearby VIA Rail station will fall below ENCG criteria for stationary noise. Thus, the idle trains are predicted to have minimal effects on the study site, and the proposed development is expected to be compatible with the existing land uses.

Regarding stationary noise impacts from the development on the surroundings, these can be minimized by judicious placement mechanical equipment such as its placement on a roof or in a mechanical penthouse, or the incorporation of silencers and noise screens as necessary. Due to the size and nature of the development, the HVAC equipment is expected to be located in the mechanical penthouses and comply with the ENCG Sound Level Limits and City of Ottawa Noise By-Law No. 2017-255.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Colonnade BridgePort to undertake a detailed environmental noise study for the proposed mixed-use development, located at 25 Pickering Place in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations related to a detailed traffic noise study.

The present scope of work involves assessing exterior noise levels at the study site generated by the surrounding transportation sources. The assessment was performed based on theoretical noise calculation methods conforming to the City of Ottawa[4] and Ministry of the Environment, Conservation and Parks (MECP) NPC-300[5] guidelines, site plan drawings received from Hobin Architecture in February 2024, with future roadway traffic volumes corresponding with the City of Ottawa's Official Plan (OP) roadway classifications and Ministry of Transportation Ontario (MTO) highway traffic data.

2. TERMS OF REFERENCE

The proposed development comprises of two mixed-use buildings. Building A, spanning 28 storeys and located on the west, while building B spans 14 storeys and is on the east. The first floors of both buildings contain commercial/retail space, and the remaining floors are residential.

The major contributors of roadway traffic noise are Tremblay Road, Belfast Road, and Highway 417. Additionally, rail traffic noise is present and due to proximity of the VIA Rail lines to the south, and O-train line to the north. The study site is surrounded by commercial, retail, and office space. Figure 1 illustrates a complete site plan with surrounding context.

Other sources of traffic noise such as Terminal Avenue were deemed insignificant due to the large offset distances between them and the site. Additionally, nearby local roads such as Pickering Place were deemed insignificant, due to their low traffic volumes.

The study site is also in close proximity to the Ottawa VIA Rail station. There are stationary noise sources associated with the station, primarily consisting of idling locomotives.

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[4] City of Ottawa Environmental Noise Control Guidelines, January 2016

[5] Ministry of the Environment, Conservation and Parks (MECP), Environmental Noise Guideline – Publication NPC-300, August 2013

Regarding stationary noise impacts from the development on the surroundings, these can be minimized by judicious placement mechanical equipment such as its placement on a roof or in a mechanical penthouse, or the incorporation of silencers and noise screens as necessary. Due to the size and nature of the development, the HVAC equipment is expected to be located in the mechanical penthouses and comply with the ENCG Sound Level Limits and City of Ottawa Noise By-Law No. 2017-255.

3. OBJECTIVES

The main goals of this work are to (i) calculate the future noise and vibration levels on the study site produced by local transportation, (ii) ensure that interior noise levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines as outlined in Section 4 of this report.

4. METHODOLOGY

4.1 Background

Noise can be defined as any obtrusive sound. It is created at a source, transmitted through a medium, such as air and intercepted by a receiver. Noise may be characterized in terms of the power of the source or the sound pressure at a specific distance. While the power of a source is characteristic of that particular source, the sound pressure depends on the location of the receiver and the path that the noise takes to reach the receiver. Measurement of noise is based on the decibel unit, dBA, which is a logarithmic ratio referenced to a standard noise level (2×10^{-5} Pascals). The 'A' suffix refers to a weighting scale, which better represents how the noise is perceived by the human ear. With this scale, a doubling of power results in a 3 dBA increase in measured noise levels and is just perceptible to most people. An increase of 10 dBA is often perceived to be twice as loud.

4.2 Transportation Noise

4.2.1 Criteria for Transportation Noise

For vehicle traffic, the equivalent sound energy level, L_{eq}, provides a measure of the time varying noise levels, which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a period of time. For roadways, the L_{eq} is commonly calculated on the basis of a 16-hour (L_{eq16}) daytime (07:00-23:00)/8-hour (L_{eq8}) nighttime (23:00-07:00) split to assess its impact on residential buildings. Table 1 outlines the specified indoor noise criteria for various spaces within residential and other noise sensitive buildings, as described in NPC-300.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD) [6]

Type of Space	Time Period	L_{eq} (dBA)	
		Road	Rail
General offices, reception areas, retail stores, etc.	07:00 – 23:00	50	45
Living/dining/den areas of residences, hospitals, schools, nursing/retirement homes, day-care centers, theatres, places of worship, libraries, individual or semi-private offices, conference rooms, etc.	07:00 – 23:00	45	40
Sleeping quarters of hotels/motels	23:00 - 07:00	45	40
Sleeping quarters of residences, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	40	35

Predicted noise levels at the plane of window (POW) dictate the action required to achieve the recommended sound levels. An open window is considered to provide a 10 dBA reduction in noise while a standard closed window is capable of providing a minimum 20 dBA noise reduction[7]. Therefore, where noise levels exceed 55 dBA daytime and 50 dBA nighttime, the ventilation for the building should consider the need for having windows and doors closed, which triggers the need for forced air heating with provision for central air conditioning. Where roadway noise levels exceed 65 dBA daytime and 60 dBA

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[6] Adapted from Table C-2, Part C, Section 3.2.3 of NPC-300

[7] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125

nighttime (60 dBA daytime and 55 dBA nighttime railway noise levels), air conditioning will be required and building components will require higher levels of sound attenuation[8].

Furthermore, balconies and terraces less than 4m in depth from the façade do not require consideration as Outdoor Living Areas and were excluded from the analysis.

4.2.2 Roadway and Railway Traffic Volumes

The ENCG dictates that noise calculations should consider future sound levels based on a roadway's classification at the mature state of development. Therefore, traffic volumes for Tremblay and Belfast Roads are based on the roadway classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[9]. Average Annual Daily Traffic (AADT) volumes are then based on data in Table B1 of the ENCG for each roadway classification. Meanwhile, traffic volumes for Highway 417 were obtained from the MTO[10] and projected with 1% annual growth to 2034. Tables 2 and 3 (below) summarize the AADT values used for each roadway and railway included in this assessment.

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway Class	Speed Limit (km/h)	Ultimate AADT	Day/Night Split	Truck Volume Percentages	
					Medium Truck	Heavy Truck
Tremblay Road	2-Ln Major Collector	50	**12,000**	92/8	**7**	**5**
Belfast Road	2-Ln Minor Collector	50	**8,000**	92/8	**7**	**5**
Highway 417	Provincial Freeway	100	**189,100**	85/15	**4**	**2**

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[8] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3
[9] City of Ottawa Transportation Master Plan, November 2013
[10] Ministry of Transportation Ontario, Provincial Highway Traffic Volumes, 2019

TABLE 3: RAILWAY TRAFFIC DATA

Segment	Roadway Class	Operating Speed (km/h)	AADT Day/Night Split
VIA Rail	Passenger Rail	150	12/2
O-Train	Passenger LRT	70	540/60

4.2.3 Theoretical Traffic Noise Predictions

Noise predictions were determined by computer modelling using two programs. To provide a general sense of noise across the site, the employed software program was Predictor-Lima (TNM calculation for Roadways, ISO calculation for railways), which incorporates the United States Federal Highway Administration's (FHWA) Transportation Noise Model (TNM) 2.5. This computer program is capable of representing three-dimensional surface and first reflections of sound waves over a suitable spectrum for human hearing. A receptor grid with 5 × 5 m spacing was placed across the study site, along with a number of discrete receptors at key sensitive areas.

Although this program outputs noise contours, it is not the approved model for roadway predictions by the City of Ottawa. Therefore, the results were confirmed by performing discrete noise calculations with the Ministry of the Environment, Conservations and Parks (MECP) computerized noise assessment program, STAMSON 5.04, at key receptor locations coinciding with receptor locations in Predictor as shown in Figure 2, as well as receptor distances in Figure A1. Sound power data for railway sources was determined with the assistance of STAMSON 5.04, which incorporates the calculation model '*Sound from Trains Environment Analysis Method*' (STEAM). The impact from railway noise is then combined with roadway predictions using a logarithmic addition at each point of reception and compared to the relevant criteria.

Transportation noise calculations were performed by treating each road/rail segment as separate line sources of noise. In addition to the traffic volumes summarized in Tables 2 and 3 above, theoretical noise predictions were based on the following parameters:

- Vehicle parameters such as truck traffic volume percentages, posted speed limit, and day/night splits are summarized in Tables 2 and 3.
- Receptor heights at building A were taken to be 84 metres above grade, while building B receptors were taken to be 42 metres above grade.
- Absorptive and reflective intermediate ground surfaces based on specific source-receiver path ground characteristics.
- The study site was treated as having flat or gently sloping topography.
- LRT has been modeled using 4-car SRT in STAMSON.
- All VIA trains operating in the area are diesel trains.
- One locomotive was modelled per VIA train, with an average of four cars per train.
- Maximum operating speed of passenger trains along this corridor is 160 km/h. However, due to STAMSON limitations, a speed of 150 km/h was used.
- As there are no grade-level crossings near the development, whistles are not used.
- Rail lines are not welded.
- Eight receptors were strategically placed throughout the study area (see Figure 2).
- Receptor distances and exposure angles are illustrated in Figure A1.

4.3 Stationary Noise

4.3.1 Criteria for Stationary Noise

For stationary sources, the L_{eq} is commonly calculated on an hourly interval, while for roadways, the L_{eq} is calculated on the basis of a 16-hour daytime/8-hour nighttime split as previously mentioned in Section 4.2.1.

Noise criteria taken from the NPC-300 apply to outdoor points of reception (POR). A POR is defined under NPC-300 as “any location on a noise sensitive land use where noise from a stationary source is received”[11]. This applies to the plane of window and outdoor amenity spaces serving the development. The surrounding area of the development would be defined as a Class 1 (Urban) environment, as background noise levels are dominated by human activities such as roadway and transit sources. The exclusionary sound level limits for Class 1 areas are summarized in Table 4 below. In a Class 1 are daytime (07:00-19:00)

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[11] NPC – 300, page 14

and evening (19:00 to 23:00) criteria are identical and for simplicity the results presented in this report combine these two periods for a daytime period of (07:00 to 23:00). The applicable sound level limit is the higher of either the values in Table 4 or background noise levels due to sources such as transportation.

TABLE 4: EXCLUSIONARY LIMITS FOR CLASS 1 AREA

Time of Day	Class 1	
	Outdoor Points of Reception	Plane of Window
07:00 – 19:00	50	50
19:00 – 23:00	50	50
23:00 – 07:00	N/A	45

4.3.2 Assumptions

Stationary sources of noise were identified based on a review of aerial imagery. A stationary source is defined as any source of noise within a single property boundary; therefore, the impact of separate properties has been assessed individually. Based on the information gathered, the following assumptions have been included in the analysis:

(i) The only source of stationary noise impacting the site is idling locomotives associated with the VIA Rail station to the southeast of the study site.
(ii) It is assumed that a single locomotive may idle for 1 hour during the daytime period, and 30 minutes during the nighttime period.
(iii) Idling locomotive is assumed to be locate in a reasonable worst-case location within the VIA Rail corridor, based on a review of satellite imagery and platform locations.
(iv) Sound power data for the idling locomotive is based on Gradient Wind’s experience with other projects.
(v) Screening effects of buildings have been considered in the modelling.

4.3.3 Determination of Noise Source Power Levels

Sound power data for the idling locomotive is based on Gradient Wind's experience with other projects, where on-site measurements of VIA Rail locomotives has been conducted. Table 5 summarizes the sound power assumed for each source used in the analysis.

TABLE 5: EQUIPMENT SOUND POWER LEVELS (dBA)

Source ID	Description	Frequency (Hz)								
		63	125	250	500	1000	2000	4000	8000	Total
S1	Idle Locomotive	82	85	89	93	92	93	90	81	99

4.3.4 Steady-State Source Noise Predictions

The impact of the surrounding stationary noise sources on the development was determined by computer modelling. Stationary noise source modelling is based on the software program *Predictor-Lima* developed from the International Standards Organization (ISO) standard 9613 Parts 1 and 2. This computer program is capable of representing three-dimensional surfaces and first reflections of sound waves over a suitable spectrum for human hearing. The methodology has been used on numerous assignments and has been accepted by the MECP as part of Environmental Compliance Approvals applications.

Eight individual noise sensor locations were selected in the *Predictor-Lima* model to measure the noise impact at points of reception (POR) during the daytime (07:00 – 19:00) and nighttime (19:00 – 07:00) periods (see Figure 2). POR locations included the plane of windows (POW's) of the development. The idling locomotive was represented as a point source in the model. Air temperature, pressure and humidity were set to 10°C, 101.3 kPA and 70%, respectively. Ground absorption over the study area was determined based on topographical features (such as water, concrete, grassland, etc.). A coefficient of 0 was used for hard surfaces, such as concrete and paved areas, and 1 for soft surfaces, such as grass and vegetative areas. Existing and proposed buildings were added to the model to account for screening and reflection effects from building façades. Modelling files and outputs are available upon request.

4.4 Ground Vibration & Ground-borne Noise

Rail systems and heavy vehicles on roadways can produce perceptible levels of ground vibrations, especially when they are in close proximity to residential neighbourhoods or vibration-sensitive buildings. Similar to sound waves in air, vibrations in solids are generated at a source, propagated through a medium, and intercepted by a receiver. In the case of ground vibrations, the medium can be uniform, or more often, a complex layering of soils and rock strata. Also, similar to sound waves in air, ground vibrations produce perceptible motions and regenerated noise known as ‘ground-borne noise’ when the vibrations encounter a hollow structure such as a building. Ground-borne noise and vibrations are generated when there is an excitation of the ground, such as from a train or subway. The repetitive motion of the wheels on the track or rubber tires passing over an uneven surface causes vibration to propagate through the soil. When they encounter a building, vibrations pass along the structure of the building beginning at the foundation and propagating to all floors. Air inside the building excited by the vibrating walls and floors represents regenerated airborne noise. Characteristics of the soil and the building are imparted to the noise, thereby creating a unique noise signature.

Human response to ground vibrations is dependent on the magnitude of the vibrations, which is measured by the root mean square (RMS) of the movement of a particle on a surface. Typical units of ground vibration measures are millimeters per second (mm/s), or inch per second (in/s). Since vibrations can vary over a wide range, it is also convenient to represent them in decibel units, or dBV. In North America, it is common practice to use the reference value of one micro-inch per second (µin/s) to represent vibration levels for this purpose. The threshold level of human perception to vibrations is about 0.10 mm/s RMS or about 72 dBV. Although somewhat variable, the threshold of annoyance for continuous vibrations is 0.5 mm/s RMS (or 85 dBV), five times higher than the perception threshold, whereas the threshold for significant structural damage is 10 mm/s RMS (or 112 dBV), at least one hundred times higher than the perception threshold level.

4.4.1 Ground Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land uses next to transit corridors. Similar standards have been developed by the MECP. These standards indicate that the appropriate criterion for residences is 0.10 mm/s RMS for vibrations. For main line railways, a document titled *Guidelines for New Development in Proximity to Railway Operations*[12], indicates that vibration conditions should not exceed 0.14 mm/s RMS averaged over a one second time-period at the first floor and above of the proposed building. The Federal Transportation Authority (FTA) criterion was adopted as the appropriate standard for this study. As the main vibration source is due to a mainline railway which has infrequent events, the 0.14 mm/s RMS (75 dBV) vibration criteria and 40 dBA ground borne noise criteria were adopted for this study.

4.4.2 Theoretical Ground Vibration Prediction Procedure

Potential vibration impacts of the trains were predicted using the Federal Transit Authority's (FTA) Transit Noise and Vibration Impact Assessment[13] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure on the following page, are based on ground vibration measurements at various transit systems throughout North America. Vibration levels at points of reception are adjusted by various factors to incorporate known characteristics of the system being analyzed, such as operating speed of vehicle, conditions of the track, construction of the track and geology, as well as the structural type of the impacted building structures. The vibration impact on the building was determined using a set of curves for locomotive powered passenger or freight vehicles at a speed of 50 mph. Adjustment factors were considered based on the following information:

- The estimated speed is 150 km/h (93 mph) as the train approaches the station.
- The distance between the development and the closest track is 60 m.
- The vehicles are assumed to have soft primary suspensions.
- Tracks are not welded, though in otherwise good condition.
- Soil conditions do not efficiently propagate vibrations.
- The building's foundation is large masonry on piles.

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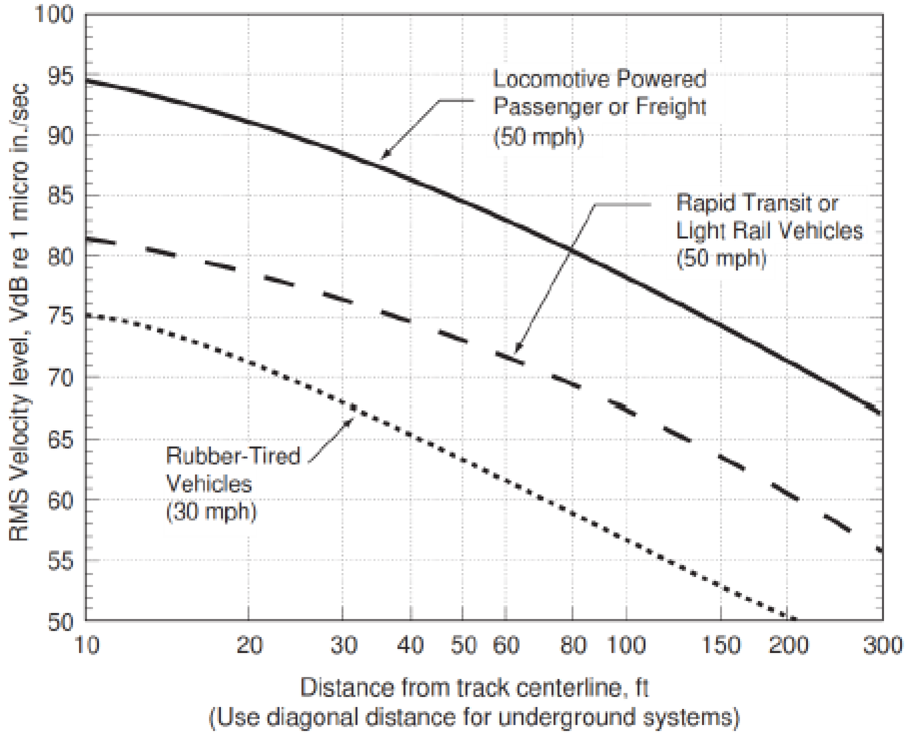
[12] Dialog and J.E. Coulter Associates Limited, prepared for The Confederation of Canadian Municipalities and The Railway Association of Canada, May 2013

[13] Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual, September 2018



FTA GENERALIZED CURVES OF VIBRATION LEVELS VERSUS DISTANCE (ADOPTED FROM FIGURE 6.4, FTA TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT)

5. RESULTS

5.1 Transportation Noise Levels

The results of the current analysis indicate that noise levels at the plane of window receptors due to roadway sources will range between 47 and 68 dBA during the daytime period (07:00-23:00) and between 40 and 63 dBA during the nighttime period (23:00-07:00). For railway sources, noise levels range between 51 and 57 dBA for the daytime period and 62 to 67 dBA during the nighttime period. The highest total noise level (i.e., 68 dBA) occurs at the north side of buildings A and B, which are most exposed to Tremblay Road, Highway 417, and the O-Train.

TABLE 6: EXTERIOR NOISE LEVELS DUE TO TRAFFIC SOURCES (PREDICTOR-LIMA)

Receptor Number	Receptor Location	Roadway Noise Level (dBA)		Railway Noise Level (dBA)		Total Noise Level (dBA)	
		Day	Night	Day	Night	Day	Night
1	POW: A – North	68	63	52	46	**68**	**63**
2	POW: A – East	64	59	54	50	**64**	**60**
3	POW: A – South	47	42	57	52	**57**	**52**
4	POW: A – West	64	60	55	50	**65**	**60**
5	POW: B – North	68	63	51	45	**68**	**63**
6	POW: B – East	64	60	55	50	**65**	**60**
7	POW: B – South	47	40	57	53	**57**	**53**
8	POW: B – West	63	59	54	50	**64**	**60**

Table 7 below shows a comparison between Predictor-Lima and STAMSON. Noise levels calculated in STAMSON were found to have a strong correlation with Predictor-Lima and variability between the two programs was within an acceptable level of ±0-3 dBA.

TABLE 7: EXTERIOR NOISE LEVEL COMPARISON

Receptor Number	Receptor Location	Predictor Noise Level (dBA)		STAMSON Noise Level (dBA)	
		Day	Day	Day	Night
5	POW: B – North	68	63	70	66
7	POW: B – South	57	53	59	55

The results of the comparison between the Predictor-Lima and STAMSON analysis indicate that the STAMSON values are more conservative, but otherwise very similar. The difference between the analyses are equal to and less than 3 dBA, which is considered imperceivable to most human observers The STAMSON roadway traffic calculations can be found in Appendix A respectively.

5.1.1 Noise Control Measures

The noise levels predicted due to roadway traffic exceed the criteria listed in Section 4.2 for building components for the development. As discussed in Section 4.2, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels + safety factor). As per NPC-300 requirements, detailed STC calculations will be required to be completed prior to building permit application for each unit type. The STC requirements for the windows are summarized below for various units within the development (see Table 8). Where specific updated building components are not identified, bedroom/living room/retail windows are to satisfy Ontario Building Code (OBC 2020) requirements.

TABLE 8: NOISE CONTROL REQUIREMENTS

Façade	Building	Bedroom / Living room Window STC	Exterior Wall STC	Warning Clauses	A/C
All	A, B	30	45	D	Yes

5.2 Stationary Noise Impacts

The results of the stationary noise calculations for the daytime and nighttime period, covering the facades of buildings A and B, are shown in Figures 3 and 4. Noise levels at nearby sensitive receptors fall below ENCG criteria for stationary noise, as summarized in Table 9 below. With consideration of Gradient Wind's assumptions, the proposed development is expected to be compatible with the existing land uses. The sound levels listed in Table 9 are based on the assumptions outlined in Section 4.3.2.

TABLE 9: NOISE LEVELS FROM STEADY-STATE STATIONARY SOURCES

Receptor Number	Receptor Location	Rail Yard Noise Level (dBA)		MECP Class 1 Criteria	
		Day	Night	Day	Night
1	POW: A – North	23	20	50	45
2	POW: A – East	46	43	50	45
3	POW: A – South	46	43	50	45
4	POW: A – West	33	40	50	45
5	POW: B – North	24	21	50	45
6	POW: B – East	35	32	50	45
7	POW: B – South	48	45	50	45
8	POW: B – West	42	39	50	45

5.3 Ground Vibrations & Ground-Borne Noise Levels

Estimated vibration levels were calculated between the building facade and the nearest streetcar track. These vibration levels were found to be 0.090 mm/s RMS (71 dBV) based on the FTA protocol and a conservative offset distance of 60 m to the nearest railway track centerline. Details of the calculation are provided in Appendix B. Due to minimal impacts; no vibration mitigation is required.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels at the plane of window receptors due to roadway sources will range between 47 and 68 dBA during the daytime period (07:00-23:00) and between 40 and 63 dBA during the nighttime period (23:00-07:00). For railway sources, noise levels range between 51 and 57 dBA for the daytime period and 62 to 67 dBA during the nighttime period. The highest total noise level (i.e., 68 dBA) occurs at the north side of buildings A and B, which are most exposed to Tremblay Road, Highway 417, and the O-Train. Building components with a higher Sound Transmission Class (STC) rating will be required where exterior noise levels exceed 65 dBA, as indicated in Table 8.

Results of the calculations also indicate that the building will require forced air heating systems with central air conditioning, or similar mechanical system, which will allow occupants to keep windows closed and maintain a comfortable living/working environment. The following Type D Warning Clause[14] will be required on all Lease, Purchase and Sale Agreements, as summarized below.

Type D:

> *"This dwelling unit has been supplied with a central air conditioning system which will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."*

Results indicate that stationary noise levels due to idle trains at the nearby VIA Rail station will fall below ENCG criteria for stationary noise. Thus, the idle trains are predicted to have minimal effects on the study site, and the proposed development is expected to be compatible with the existing land uses.

Regarding stationary noise impacts from the development on the surroundings, these can be minimized by judicious placement mechanical equipment such as its placement on a roof or in a mechanical penthouse, or the incorporation of silencers and noise screens as necessary. Due to the size and nature of the development, the HVAC equipment is expected to be located in the mechanical penthouses and comply with the ENCG Sound Level Limits and City of Ottawa Noise By-Law No. 2017-255.

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[14] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 8

This concludes our assessment and report. If you have any questions or wish to discuss our findings, please advise us. In the interim, we thank you for the opportunity to be of service.

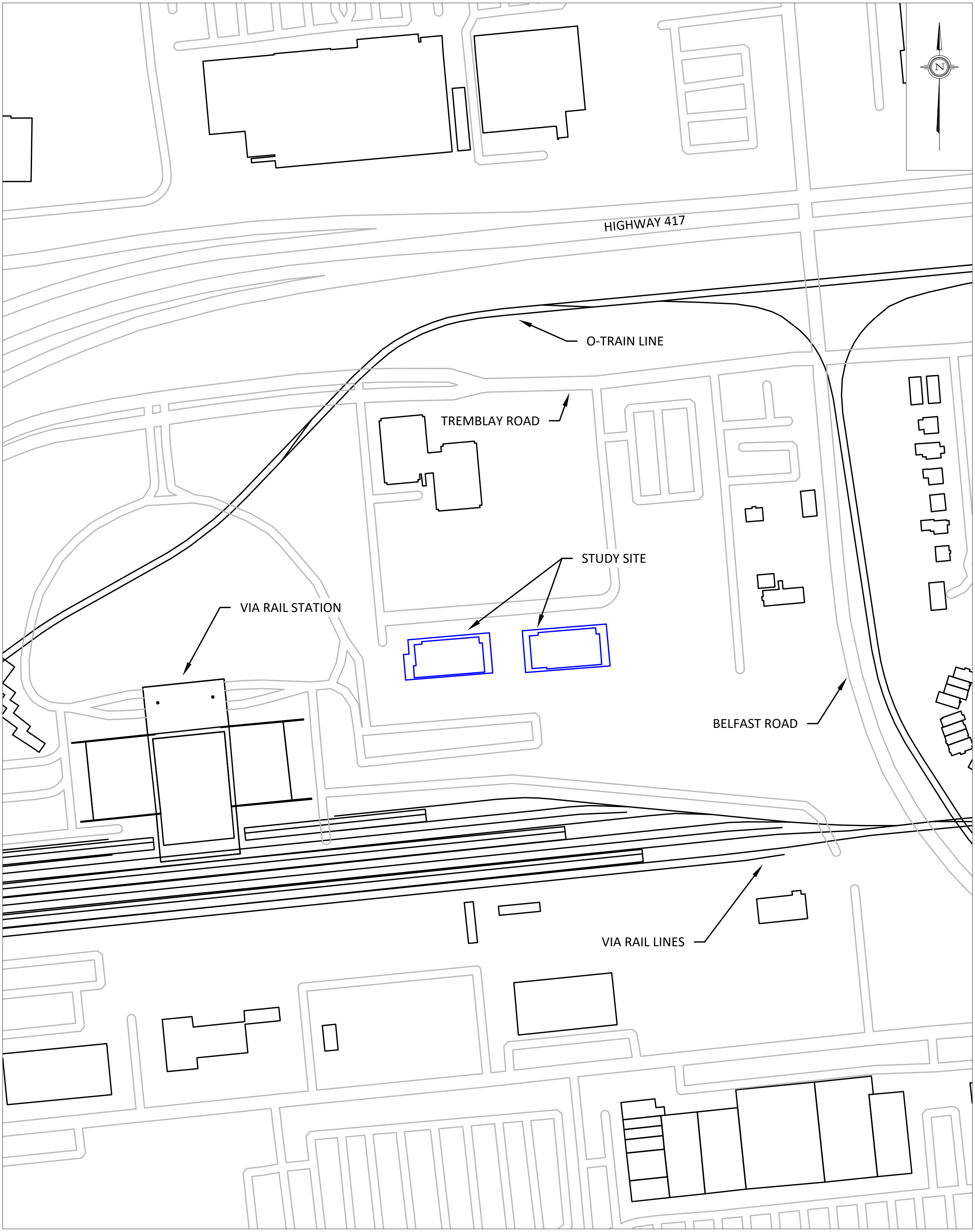
Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. R. FOSTER
100155655
May 3 2024
PROVINCE OF ONTARIO

Adam Bonello, BASc.	Joshua Foster, P.Eng.
Junior Environmental Scientist	Lead Engineer

Gradient Wind File #24-031-Detailed Environmental Noise Study



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127 WALGREEN ROAD , OTTAWA, ON
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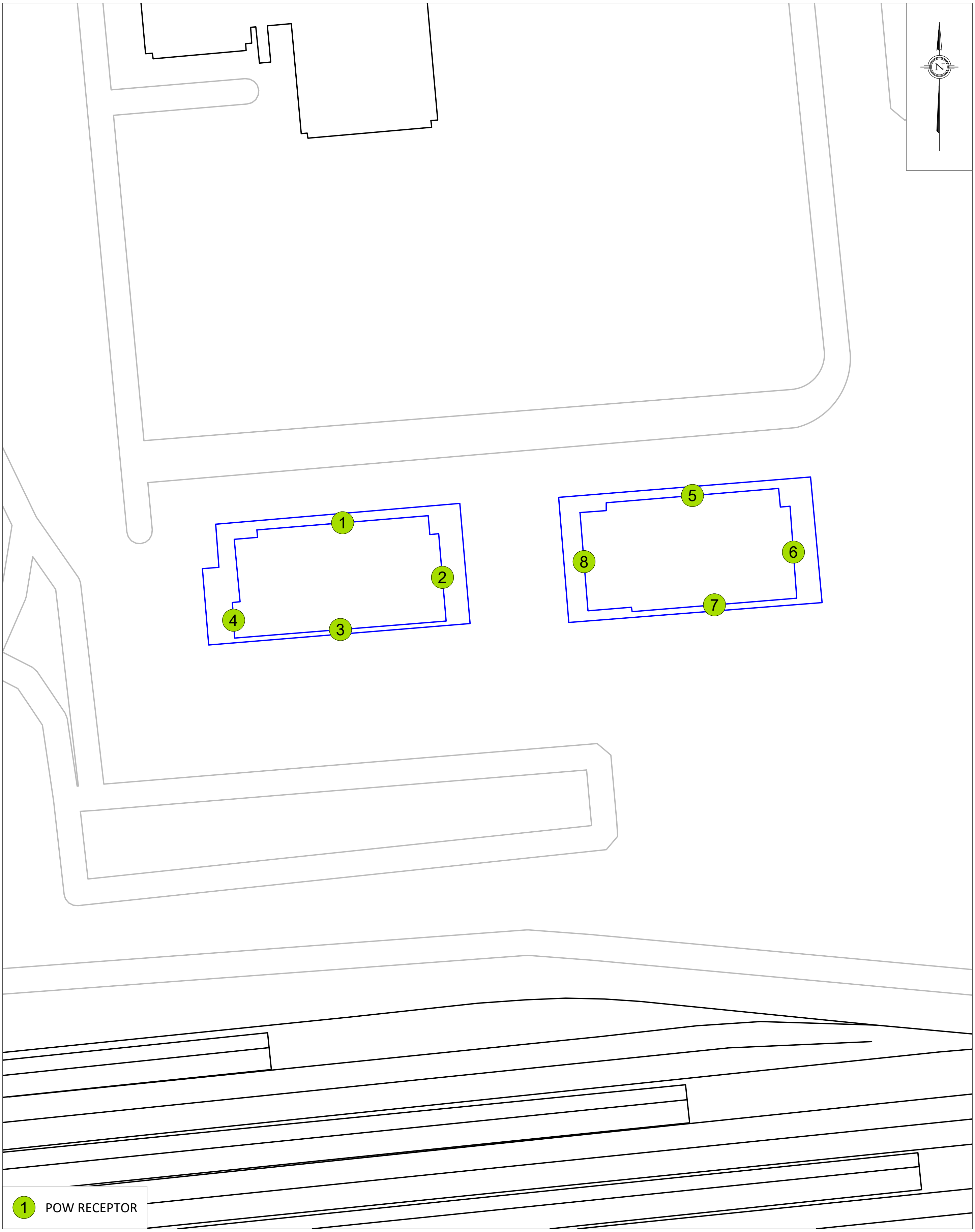
PROJECT	25 PICKERING PLACE, OTTAWA DETAILED ENVIRONMENTAL NOISE ASSESSMENT
SCALE	1:3000 (APPROX.)
DRAWING NO.	GW24-031-1
DATE	MARCH 22, 2024
DRAWN BY	A.B.
DESCRIPTION	FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT



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PROJECT	25 PICKERING PLACE, OTTAWA DETAILED ENVIRONMENTAL NOISE ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW24-031-2
DATE	MARCH 22, 2024	DRAWN BY	A.B.

DESCRIPTION

FIGURE 2:
TRAFFIC NOISE RECEPTOR LOCATIONS

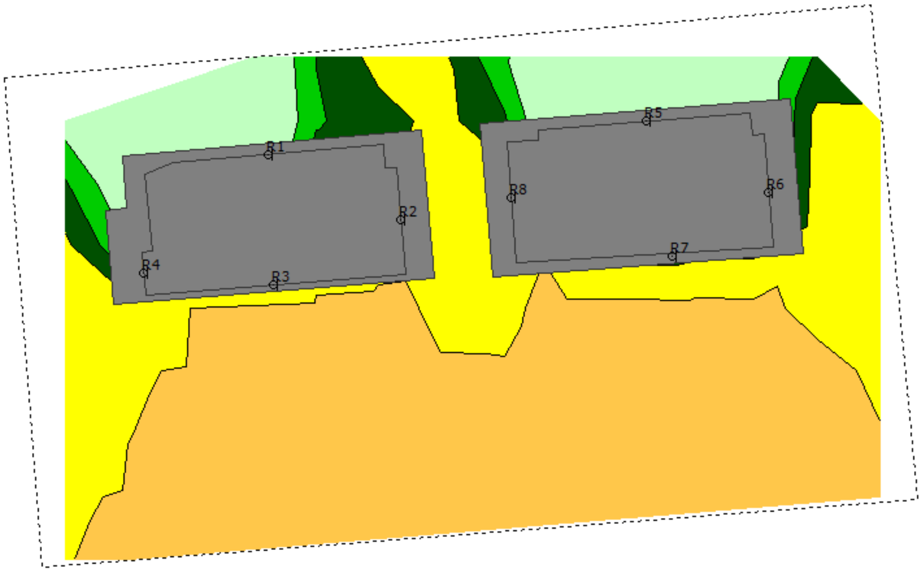

FIGURE 3: DAYTIME STATIONARY NOISE CONTOURS

🟦 *80 – 85 dB*
🟦 *75 – 80 dB*
🟪 *70 – 75 dB*
🟥 *65 – 70 dB*
🟥 *60 – 65 dB*
🟧 *55 – 60 dB*
🟧 *50 – 55 dB*
🟨 *45 – 50 dB*
🟩 *40 – 45 dB*
🟩 *35 – 40 dB*
🟩 *0 – 35 dB*

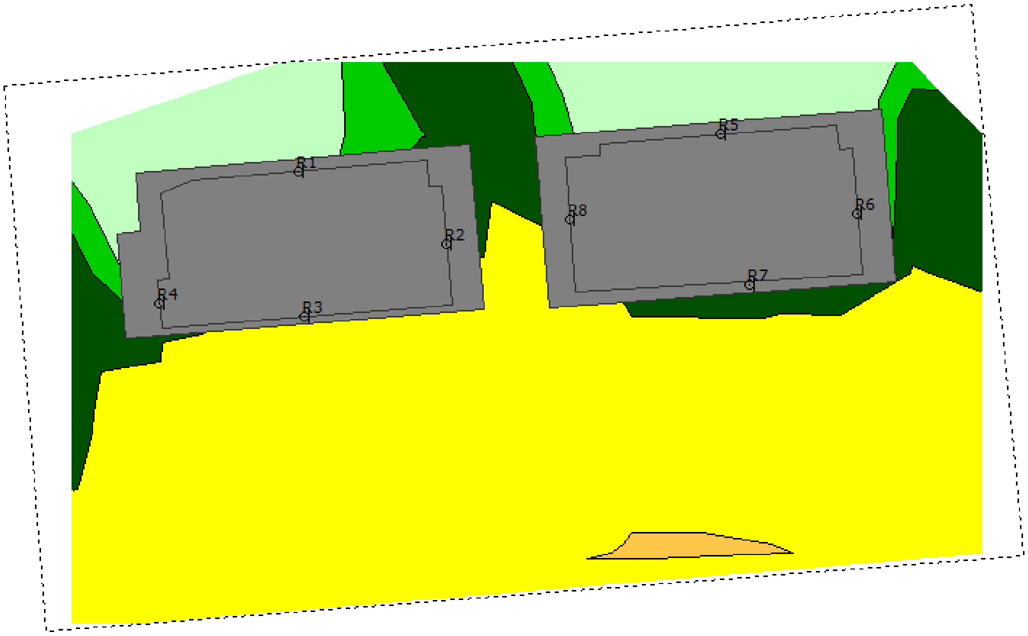

FIGURE 4: NIGHTTIME STATIONARY NOISE CONTOURS

- 🟦 *80 – 85 dB*
- 🟦 *75 – 80 dB*
- 🟪 *70 – 75 dB*
- 🟥 *65 – 70 dB*
- 🟥 *60 – 65 dB*
- 🟧 *55 – 60 dB*
- 🟧 *50 – 55 dB*
- 🟨 *45 – 50 dB*
- 🟩 *40 – 45 dB*
- 🟩 *35 – 40 dB*
- 🟩 *0 – 35 dB*

APPENDIX A

STAMSON 5.04 – INPUT AND OUTPUT DATA

GRADIENTWIND
ENGINEERS & SCIENTISTS

127 WALGREEN ROAD , OTTAWA, ON
613 836 0934 • GRADIENTWIND.COM

PROJECT	25 PICKERING PLACE, OTTAWA DETAILED ENVIRONMENTAL NOISE ASSESSMENT
SCALE	1:2000 (APPROX.)
DRAWING NO.	GW24-031-A1
DATE	MARCH 22, 2024
DRAWN BY	A.B.
DESCRIPTION	FIGURE A1: STAMSON RECEPTOR DISTANCES AND EXPOSURE ANGLES

```
STAMSON 5.0        NORMAL REPORT        Date: 21-03-2024 16:09:00
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5.te                  Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: Belfast (day/night)
-------------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Belfast (day/night)
-----------------------------------------
Angle1   Angle2           : -90.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 163.00 / 163.00 m
Receiver height           :  42.00 / 42.00  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Road data, segment # 2: Tremblay (day/night)
--------------------------------------------
Car traffic volume  :  9715/845   veh/TimePeriod  *
Medium truck volume :   773/67    veh/TimePeriod  *
Heavy truck volume  :   552/48    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  12000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00
```

```
Data for Segment # 2: Tremblay (day/night)
------------------------------------------
Angle1   Angle2            : -90.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   : 146.00 / 146.00 m
Receiver height            :  42.00 / 42.00  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -45.00 deg   Angle2 : -20.00 deg
Barrier height             :  18.00 m
Barrier receiver distance  :  37.00 / 37.00  m
Source elevation           :   0.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00

Road data, segment # 3: Highway 417 (day/night)
-----------------------------------------------
Car traffic volume  : 151091/26663 veh/TimePeriod  *
Medium truck volume :  6429/1135  veh/TimePeriod  *
Heavy truck volume  :  3215/567   veh/TimePeriod  *
Posted speed limit  :   100 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT): 189100
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   4.00
    Heavy Truck  % of Total Volume     :   2.00
    Day (16 hrs) % of Total Volume     :  85.00

Data for Segment # 3: Highway 417 (day/night)
---------------------------------------------
Angle1   Angle2            : -90.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      1 / 1
House density              :     30 %
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   : 233.00 / 233.00 m
Receiver height            :  42.00 / 42.00  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -45.00 deg   Angle2 : -20.00 deg
Barrier height             :  18.00 m
Barrier receiver distance  :  37.00 / 37.00  m
Source elevation           :   0.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00
```

```
Results segment # 1: Belfast (day)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 52.38 + 0.00) = 52.38 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90      0   0.00  65.75   0.00 -10.36  -3.01   0.00   0.00   0.00  52.38
--------------------------------------------------------------------------

Segment Leq : 52.38 dBA

Results segment # 2: Tremblay (day)
-----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !       42.00 !       31.74 !        31.74

ROAD (51.61 + 49.06 + 55.49) = 57.63 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    -45   0.00  67.51   0.00  -9.88  -6.02   0.00   0.00   0.00  51.61
--------------------------------------------------------------------------
   -45    -20   0.00  67.51   0.00  -9.88  -8.57   0.00   0.00   0.00  49.06*
   -45    -20   0.00  67.51   0.00  -9.88  -8.57   0.00   0.00   0.00  49.06
--------------------------------------------------------------------------
   -20     90   0.00  67.51   0.00  -9.88  -2.14   0.00   0.00   0.00  55.49
--------------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 57.63 dBA

Results segment # 3: Highway 417 (day)
--------------------------------------

Source height = 1.19 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.19 !       42.00 !       35.52 !        35.52

ROAD (64.06 + 61.51 + 67.94) = 70.08 dBA
```

```
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
------------------------------------------------------------------------------
   -90    -45   0.00  83.30   0.00 -11.91  -6.02   0.00  -1.31   0.00  64.06
------------------------------------------------------------------------------
   -45    -20   0.00  83.30   0.00 -11.91  -8.57   0.00  -1.31   0.00  61.51
   -45    -20   0.00  83.30   0.00 -11.91  -8.57   0.00   0.00   0.00  62.81*
   -45    -20   0.00  83.30   0.00 -11.91  -8.57   0.00   0.00   0.00  62.81
------------------------------------------------------------------------------
   -20     90   0.00  83.30   0.00 -11.91  -2.14   0.00  -1.31   0.00  67.94
------------------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 70.08 dBA

Total Leq All Segments: 70.39 dBA

Results segment # 1: Belfast (night)
-------------------------------------

Source height = 1.50 m

ROAD (0.00 + 44.79 + 0.00) = 44.79 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
------------------------------------------------------------------------------
   -90      0   0.00  58.16   0.00 -10.36  -3.01   0.00   0.00   0.00  44.79
------------------------------------------------------------------------------

Segment Leq : 44.79 dBA

Results segment # 2: Tremblay (night)
--------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
-------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
-------------+--------------+--------------+---------------
       1.50 !       42.00 !       31.74 !        31.74

ROAD (44.01 + 41.46 + 47.89) = 50.03 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
------------------------------------------------------------------------------
   -90    -45   0.00  59.91   0.00  -9.88  -6.02   0.00   0.00   0.00  44.01
------------------------------------------------------------------------------
   -45    -20   0.00  59.91   0.00  -9.88  -8.57   0.00   0.00   0.00  41.46*
   -45    -20   0.00  59.91   0.00  -9.88  -8.57   0.00   0.00   0.00  41.46
------------------------------------------------------------------------------
   -20     90   0.00  59.91   0.00  -9.88  -2.14   0.00   0.00   0.00  47.89
------------------------------------------------------------------------------
```

```
 * Bright Zone !

Segment Leq : 50.03 dBA

Results segment # 3: Highway 417 (night)
----------------------------------------

Source height = 1.19 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
-------------+--------------+--------------+---------------
       1.19 !        42.00 !        35.52 !         35.52

ROAD (59.54 + 56.98 + 63.42) = 65.56 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------------
   -90    -45   0.00  78.77   0.00 -11.91  -6.02   0.00  -1.31   0.00  59.54
--------------------------------------------------------------------------------
   -45    -20   0.00  78.77   0.00 -11.91  -8.57   0.00  -1.31   0.00  56.98
   -45    -20   0.00  78.77   0.00 -11.91  -8.57   0.00   0.00   0.00  58.29*
   -45    -20   0.00  78.77   0.00 -11.91  -8.57   0.00   0.00   0.00  58.29
--------------------------------------------------------------------------------
   -20     90   0.00  78.77   0.00 -11.91  -2.14   0.00  -1.31   0.00  63.42
--------------------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 65.56 dBA

Total Leq All Segments: 65.72 dBA

RT/Custom data, segment # 1: O-Train (day/night)
------------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70  km/h

Data for Segment # 1: O-Train (day/night)
-----------------------------------------
Angle1   Angle2            : -90.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   : 190.00 / 190.00 m
Receiver height            :  42.00 / 42.00  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -45.00 deg   Angle2 : -20.00 deg
Barrier height             :  18.00 m
Barrier receiver distance  :  37.00 / 37.00  m
Source elevation           :   0.00 m
```

```
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00

Results segment # 1: O-Train (day)
----------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.00 !       33.92 !        33.92

RT/Custom (46.39 + 43.84 + 50.27) = 52.41 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj  SubLeq
----------------------------------------------------------------------
   -90    -45   0.00  63.44 -11.03  -6.02   0.00   0.00   0.00  46.39
----------------------------------------------------------------------
   -45    -20   0.00  63.44 -11.03  -8.57   0.00   0.00   0.00  43.84*
   -45    -20   0.00  63.44 -11.03  -8.57   0.00   0.00   0.00  43.84
----------------------------------------------------------------------
   -20     90   0.00  63.44 -11.03  -2.14   0.00   0.00   0.00  50.27
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 52.41 dBA

Total Leq All Segments: 52.41 dBA

Results segment # 1: O-Train (night)
------------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.00 !       33.92 !        33.92

RT/Custom (39.86 + 37.31 + 43.74) = 45.88 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj  SubLeq
----------------------------------------------------------------------
   -90    -45   0.00  56.91 -11.03  -6.02   0.00   0.00   0.00  39.86
----------------------------------------------------------------------
   -45    -20   0.00  56.91 -11.03  -8.57   0.00   0.00   0.00  37.31*
   -45    -20   0.00  56.91 -11.03  -8.57   0.00   0.00   0.00  37.31
----------------------------------------------------------------------
```

```
   -20     90   0.00  56.91 -11.03  -2.14   0.00   0.00   0.00  43.74
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 45.88 dBA

Total Leq All Segments: 45.88 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 70.46
                         (NIGHT): 65.76
```

```
STAMSON 5.0        NORMAL REPORT        Date: 21-03-2024 15:47:58
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R7.te                 Time Period: Day/Night 16/8 hours
Description:

Rail data, segment # 1: Rail Line (day/night)
---------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. VIA         !  12.0/2.0   ! 150.0 !  1.0 !  4.0 !Diesel!  No

Data for Segment # 1: Rail Line (day/night)
-------------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 100.00 / 100.00 m
Receiver height           :  42.00 / 42.00  m
Topography                :      1       (Flat/gentle slope; no barrier)
No Whistle
Reference angle           :   0.00

Results segment # 1: Rail Line (day)
------------------------------------

LOCOMOTIVE (0.00 + 58.49 + 0.00) = 58.49 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  66.73  -8.24   0.00   0.00   0.00   0.00  58.49
----------------------------------------------------------------------

WHEEL (0.00 + 51.57 + 0.00) = 51.57 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  59.81  -8.24   0.00   0.00   0.00   0.00  51.57
----------------------------------------------------------------------

Segment Leq : 59.29 dBA

Total Leq All Segments: 59.29 dBA

Results segment # 1: Rail Line (night)
--------------------------------------

LOCOMOTIVE (0.00 + 53.72 + 0.00) = 53.72 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  61.96  -8.24   0.00   0.00   0.00   0.00  53.72
----------------------------------------------------------------------
```

```
WHEEL (0.00 + 46.80 + 0.00) = 46.80 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  55.04  -8.24   0.00   0.00   0.00   0.00  46.80
----------------------------------------------------------------------

Segment Leq : 54.52 dBA

Total Leq All Segments: 54.52 dBA

Road data, segment # 1: Belfast (day/night)
-------------------------------------------
Car traffic volume  :  6477/563   veh/TimePeriod  *
Medium truck volume :   515/45    veh/TimePeriod  *
Heavy truck volume  :   368/32    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):   8000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Belfast (day/night)
-----------------------------------------
Angle1   Angle2           :   0.00 deg   45.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 162.00 / 162.00 m
Receiver height           :  42.00 / 42.00  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Results segment # 1: Belfast (day)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 49.39 + 0.00) = 49.39 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     0     45   0.00  65.75   0.00 -10.33  -6.02   0.00   0.00   0.00  49.39
----------------------------------------------------------------------------

Segment Leq : 49.39 dBA

Total Leq All Segments: 49.39 dBA
```

```
Results segment # 1: Belfast (night)
------------------------------------

Source height = 1.50 m

ROAD (0.00 + 41.80 + 0.00) = 41.80 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
     0     45   0.00  58.16   0.00 -10.33  -6.02   0.00   0.00   0.00  41.80
--------------------------------------------------------------------------

Segment Leq : 41.80 dBA

Total Leq All Segments: 41.80 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 59.71
                         (NIGHT): 54.75
```

APPENDIX B

FTA VIBRATION CALCULATIONS

GW24-031 22-Mar-24

Possible Vibration Impacts on Crosstown Block 6C
Predicted using FTA General Assesment

Train Speed 150 km/h 93 mph

	Distance from C/L	
	(m)	(ft)
CN	60.0	196.8

Vibration

From FTA Manual Fig 10-1		
Vibration Levels at distance from track	71.60	dBV re 1 micro in/sec
Adjustment Factors FTA Table 10-1		
Speed reference 50 mph	5.4	Speed Limit of 150 km/h (93 mph)
Vehicle Parameters	0	Assume Soft primary suspension, Weels run true
Track Condition	0	Jointed Track
Track Treatments	0	Floating Slab Trackbed
Type of Transit Structure	0	Open cut
Efficient vibration Propagation	0	Propagation through rock
Vibration Levels at Fdn	77	0.180
Coupling to Building Foundation	-10	Large Massonry on Piles
Floor to Floor Attenuation	-2.0	Ground Floor Ocupied
Amplification of Floor and Walls	6	
Total Vibration Level	71.00101	dBV or 0.090 mm/s
Noise Level in dBA	36.00101	dBA

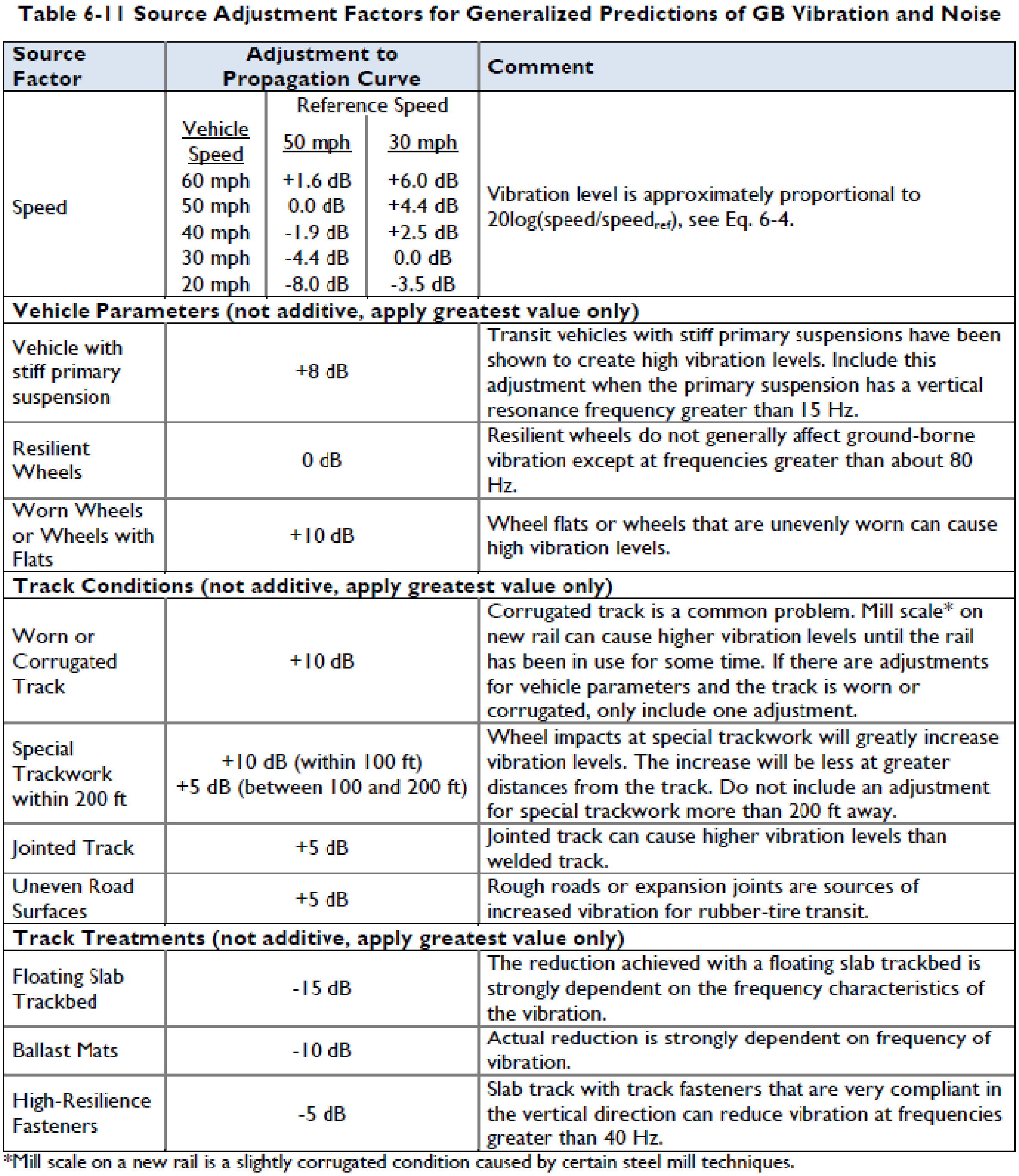

Table 6-11 Source Adjustment Factors for Generalized Predictions of GB Vibration and Noise

Source Factor	**Adjustment to Propagation Curve**			**Comment**
		Reference Speed		
Speed	Vehicle Speed	50 mph	30 mph	Vibration level is approximately proportional to 20log(speed/speed$_{ref}$), see Eq. 6-4.
	60 mph	+1.6 dB	+6.0 dB	
	50 mph	0.0 dB	+4.4 dB	
	40 mph	-1.9 dB	+2.5 dB	
	30 mph	-4.4 dB	0.0 dB	
	20 mph	-8.0 dB	-3.5 dB	
Vehicle Parameters (not additive, apply greatest value only)				
Vehicle with stiff primary suspension	+8 dB			Transit vehicles with stiff primary suspensions have been shown to create high vibration levels. Include this adjustment when the primary suspension has a vertical resonance frequency greater than 15 Hz.
Resilient Wheels	0 dB			Resilient wheels do not generally affect ground-borne vibration except at frequencies greater than about 80 Hz.
Worn Wheels or Wheels with Flats	+10 dB			Wheel flats or wheels that are unevenly worn can cause high vibration levels.
Track Conditions (not additive, apply greatest value only)				
Worn or Corrugated Track	+10 dB			Corrugated track is a common problem. Mill scale* on new rail can cause higher vibration levels until the rail has been in use for some time. If there are adjustments for vehicle parameters and the track is worn or corrugated, only include one adjustment.
Special Trackwork within 200 ft	+10 dB (within 100 ft) +5 dB (between 100 and 200 ft)			Wheel impacts at special trackwork will greatly increase vibration levels. The increase will be less at greater distances from the track. Do not include an adjustment for special trackwork more than 200 ft away.
Jointed Track	+5 dB			Jointed track can cause higher vibration levels than welded track.
Uneven Road Surfaces	+5 dB			Rough roads or expansion joints are sources of increased vibration for rubber-tire transit.
Track Treatments (not additive, apply greatest value only)				
Floating Slab Trackbed	-15 dB			The reduction achieved with a floating slab trackbed is strongly dependent on the frequency characteristics of the vibration.
Ballast Mats	-10 dB			Actual reduction is strongly dependent on frequency of vibration.
High-Resilience Fasteners	-5 dB			Slab track with track fasteners that are very compliant in the vertical direction can reduce vibration at frequencies greater than 40 Hz.

*Mill scale on a new rail is a slightly corrugated condition caused by certain steel mill techniques.

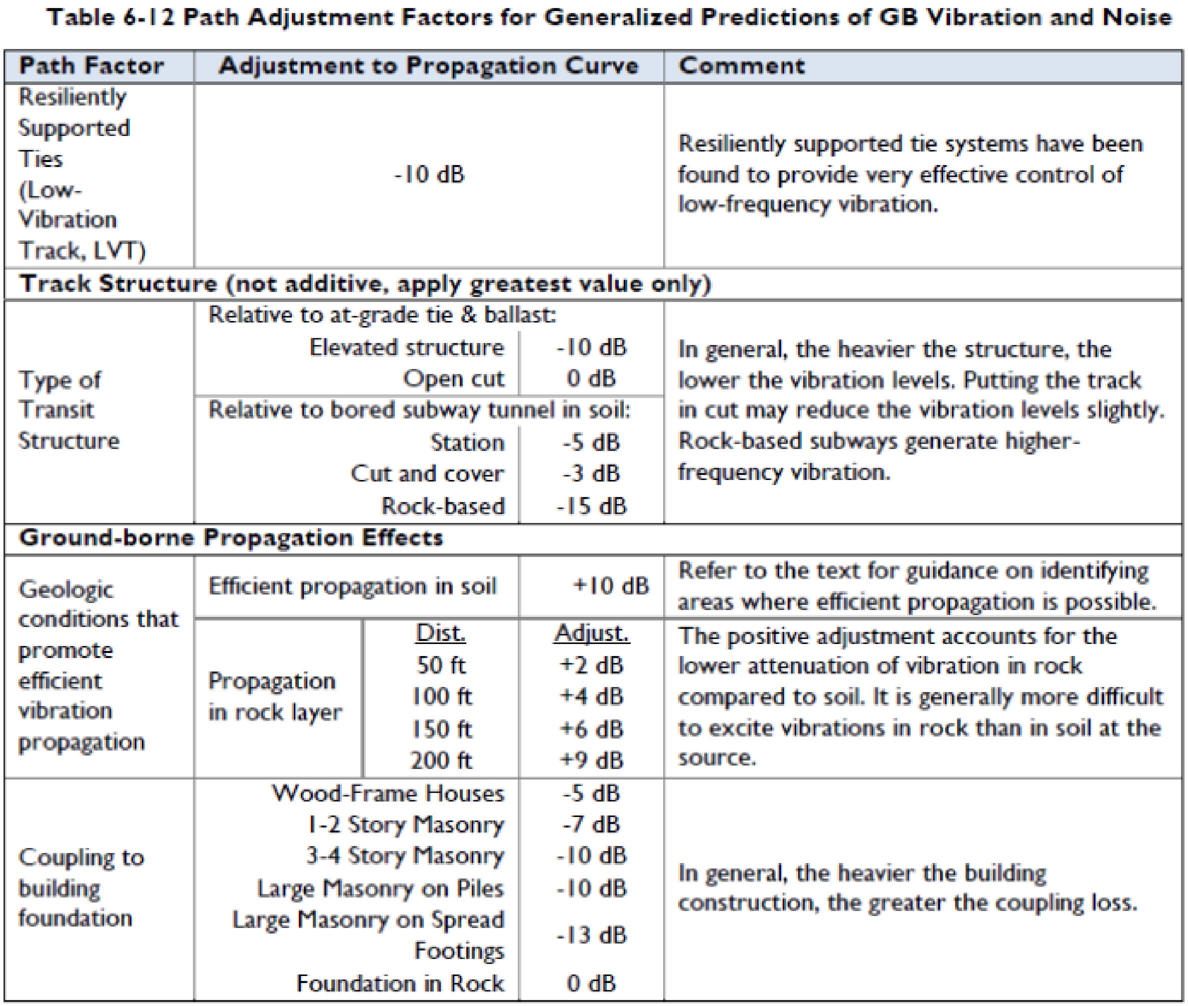

Table 6-12 Path Adjustment Factors for Generalized Predictions of GB Vibration and Noise

<table>
<tr><th>Path Factor</th><th colspan="3">Adjustment to Propagation Curve</th><th>Comment</th></tr>
<tr><td>Resiliently Supported Ties (Low-Vibration Track, LVT)</td><td colspan="3">-10 dB</td><td>Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.</td></tr>
<tr><td colspan="5">Track Structure (not additive, apply greatest value only)</td></tr>
<tr><td rowspan="7">Type of Transit Structure</td><td colspan="3">Relative to at-grade tie & ballast:</td><td rowspan="7">In general, the heavier the structure, the lower the vibration levels. Putting the track in cut may reduce the vibration levels slightly. Rock-based subways generate higher-frequency vibration.</td></tr>
<tr><td colspan="2">Elevated structure</td><td>-10 dB</td></tr>
<tr><td colspan="2">Open cut</td><td>0 dB</td></tr>
<tr><td colspan="3">Relative to bored subway tunnel in soil:</td></tr>
<tr><td colspan="2">Station</td><td>-5 dB</td></tr>
<tr><td colspan="2">Cut and cover</td><td>-3 dB</td></tr>
<tr><td colspan="2">Rock-based</td><td>-15 dB</td></tr>
<tr><td colspan="5">Ground-borne Propagation Effects</td></tr>
<tr><td rowspan="6">Geologic conditions that promote efficient vibration propagation</td><td colspan="2">Efficient propagation in soil</td><td>+10 dB</td><td>Refer to the text for guidance on identifying areas where efficient propagation is possible.</td></tr>
<tr><td rowspan="5">Propagation in rock layer</td><td>Dist.</td><td>Adjust.</td><td rowspan="5">The positive adjustment accounts for the lower attenuation of vibration in rock compared to soil. It is generally more difficult to excite vibrations in rock than in soil at the source.</td></tr>
<tr><td>50 ft</td><td>+2 dB</td></tr>
<tr><td>100 ft</td><td>+4 dB</td></tr>
<tr><td>150 ft</td><td>+6 dB</td></tr>
<tr><td>200 ft</td><td>+9 dB</td></tr>
<tr><td rowspan="6">Coupling to building foundation</td><td colspan="2">Wood-Frame Houses</td><td>-5 dB</td><td rowspan="6">In general, the heavier the building construction, the greater the coupling loss.</td></tr>
<tr><td colspan="2">1-2 Story Masonry</td><td>-7 dB</td></tr>
<tr><td colspan="2">3-4 Story Masonry</td><td>-10 dB</td></tr>
<tr><td colspan="2">Large Masonry on Piles</td><td>-10 dB</td></tr>
<tr><td colspan="2">Large Masonry on Spread Footings</td><td>-13 dB</td></tr>
<tr><td colspan="2">Foundation in Rock</td><td>0 dB</td></tr>
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